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EGG STRUCTURE OF SOME REPRESENTATIVES OF THE FAMILY PALINGENIIDAE (INSECTA: EPHEMEROPTERA)

T. M. Tiunova

Federal Scientific Center of the East Asia Terrestrial Biodiversity, Far Eastern Branch of the Russian Academy of Sciences, Vladivostok, 690022, Russia. E-mail: tiunova@biosoil.ru

Summary. Egg of two East Palaearctic species, *Anagenesia paradoxa* Buldovsky and *Chankagenesia natans* Buldovsky, from the Russian Far East were studied by scanning electron microscopy. Our studies for representatives of genera *Anagenesia* Eaton and *Chankagenesia* Buldovsky, as well as literature data for genera *Palingenia* Burmeister, *Cheirogenesia* Demoulin, and *Mortogenesia* Lestage were analysed. It was noted that eggs of all known species of the family Palingeniidae have: 1) a lens shape, biconvex in lateral projection and oval in dorsal one; 2) thin adhesive membrane film covering the egg; 3) rough or smooth surface of the chorion; 4) micropyle characterized by funnel-shaped type. The largest sizes of eggs were noted in *Mortogenesia mesopotamica* (Morton) and smallest in *Anagenesia paradoxa*.

Key words: mayflies, Palingeniidae, morphology, SEM, East Palaearctic.

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Резюме. Методом сканирующей электронной микроскопии изучены яйца двух восточнопалеарктических видов, *Anagenesia paradoxa* Buldovsky и *Chankagenesia natans* Buldovsky, с Дальнего Востока России. Проанализированы наши исследования по представителям родов *Anagenesia* Eaton и *Chankagenesia* Buldovsky, а также литературные данные по родам *Palingenia* Burmeister, *Cheirogenesia* Demoulin и *Mortogenesia* Lestage. Отмечено, что яйца всех известных видов семейства Palingeniidae имеют: 1) линзовидную форму, двояковыпуклую в латеральной проекции и овальную в дорсальной; 2) тонкую клейкую мембранную пленку, покрывающую яйцо; 3) шероховатую или гладкую поверхность хориона; 4) микропиле воронковидной формы. Наибольшие размеры яиц отмечены у представителей рода *Mortogenesia*, наименьшие – у рода *Anagenesia*.

INTRODUCTION

The family Palingeniidae currently includes six genera: genus *Anagenesia* Ulmer (represented by 15 species distributed in Eastern and Southern Asia); genus *Chankagenesia* Buldovsky (three species from Eastern Asia); genus *Cheirogenesia* Demoulin (three species

from Madagascar); genus *Mortogenesia* Lestage (one species from Iraq); genus *Palingenia* Burmeister (six species distributed in West Palaearctic, including West Siberia and a dubious record from west Africa); and genus *Plethogenesia* Ulmer (five species from New Guinea) (Barber-James *et al*., 2013; Kluge, 2025).

In the Russian Far East, the family Palingeniidae is represented by only two genera, *Anagenesia* and *Chankagenesia*, including one species each, *Anagenesia paradoxa* Buldovsky, and *Chankagenesia natans* Buldovsky.

The structure of eggs of this family has been studied only for a small number of species; using a scanning electron microscope SEM for *Palingenia longicauda* (Olivier) (Gaino & Bongiovanni, 1993; Landolt *et al*., 1995), *Cheirogenesia edmundsi* Sartori et Elouard, 1999, and *Mortogenesia mesopotamica* (Morton) (Soldán & Godunko, 2013); without a SEM for *Palingenia sublongicauda* Tshernova (Kosova, 1967), *Cheirogenesia decaryi* Navas (Sartori & Elouard, 1999). As shown previously, the eggs of the species studied differ from the classical model in Ephemeroptera, being ellipsoidal in shape and lacking attachment structures on the egg surface (Chopra, 1927; Russev, 1987; Gaino & Bongiovanni, 1993).

In the present work, the structure of eggs of two mayfly species from the genera *Anagenesia* and *Chankagenesia* are presented using a SEM. Eggs of the investigated species were compared with representatives of the genera *Palingenia*, *Cheirogenesia,* and *Mortogenesia*.

MATERIAL AND METHODS

The eggs of each species for SEM study were extracted from female imagines and larva fixed in 80% ethanol. Eggs were cleaned using a Branson digital ultrasonic cleaner. After cleaning, eggs were placed in 99% alcohol for 24 hours and examined on a Merlin 62–15 SEM. When describing the morphological structure of eggs, we used the terminology proposed by Koss & Edmunds (1974) and Ubero-Pascal & Puig (2007).

RESULTS

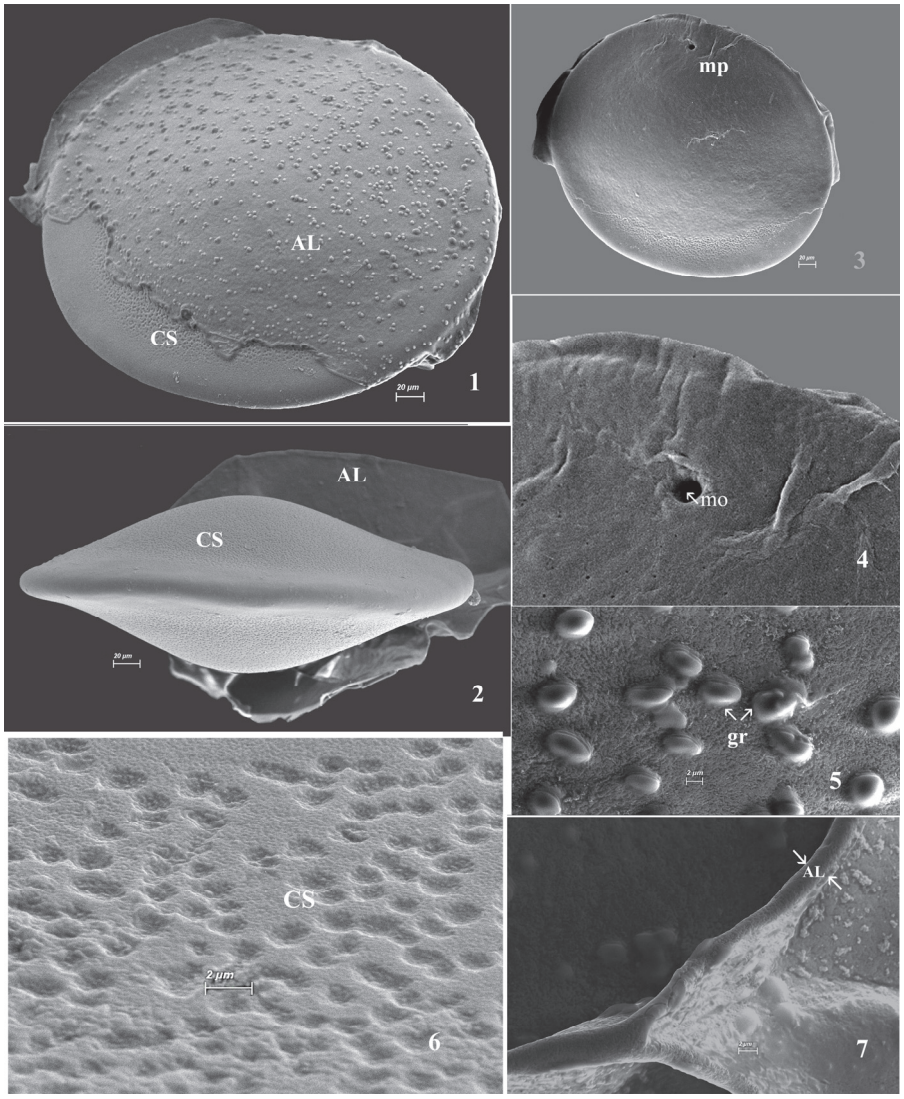
Anagenesia paradoxa Buldovsky, 1935

Figs 1–7

MATERIAL EXAMINED. Russian Federation: Primorsky Krai, Nadezhdinsky district, Razdolnaya River, right bank, 200 m below the road bridge Vladivostok–Khasan highway, ♀ imago, leg. T. Tiunova; Khabarovsky Krai, Nikolaevsky district, Middle Amur River, Troitskoye Village, 16.IX.2006, ♀ imago, leg. V. Luborez.

EGG DISCRIPTION. The egg of *A. paradoxa* is slightly oval in dorsal view (Figs 1, 3). Dimensions: 352–280 µm along the major axis and 320–260 µm along the minor axis. In lateral view, the egg is shaped like a biconvex lens-shape thickness of 136 µm with a thick peripheral border (Fig. 2). The outer adhesive layer, in the form of a membrane covering the egg, is thin, smoothly amorphous, 1.64 µm thick (Figs 1, 7), densely packed with oval-shaped granules (Figs 1, 5). Each egg has only one micropyle under the peripheral border (Fig. 3). The edges of the micropyle are weakly prominent above the surface of the chorion (Fig. 4). The micropylar opening is nearly round, 8.4–10.5 µm wide and 6.4–9.7 µm high (Fig. 4). Thus, the eggs of *A. paradoxa* are characterized by a funnel-form micropyle (Figs 3, 4). In this type of micropyle, 'the micropylar canal either issues from the base and near the center of a funnel-shaped sperm guide, and is perpendicular to or acutely angled with the chorion; or else the sperm guide is lacking or not readily discernible, and a portion of the micropylar canal is definitely perpendicular or nearly so to the chorion at least throughout most of the chorion's depth' (Koss & Edmunds 1974). The sculpture of the chorion consists of shallow rounded notches, whose arrangement regularly covers the entire surface of the chorion (Fig. 6).

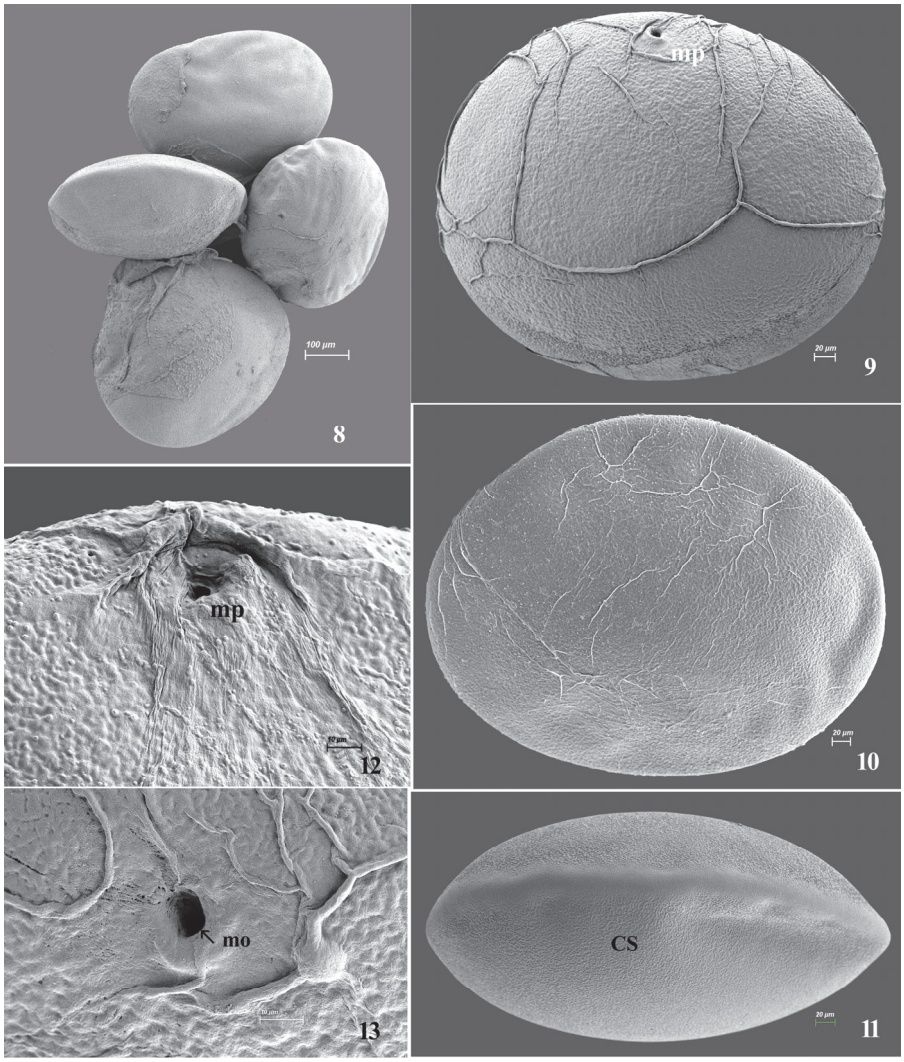
DISTRIBUTION. South of the Russian Far East: middle and lower reaches of the Amur River, Khanka Lake, and Razdolnaya River.



Figs 1–7. Egg morphology of *Anagenesia paradoxa* Buldovsky: 1 – general shape with adhesive layer, dorsal view; 2– lateral view; 3 – location of the micropyle, dorsal view; 4 – shape of the micropyle; 5 – shape of granules on the adhesive layer; 6 – chorionic sculpturing; 7 – thickness of adhesive layer. AL – adhesive layer; CS – chorion surface; mo – micropylar opening; mp – micropyle; gr – granules.

***Chankagenesia natans* Buldovsky, 1935**
Figs 8 – 17

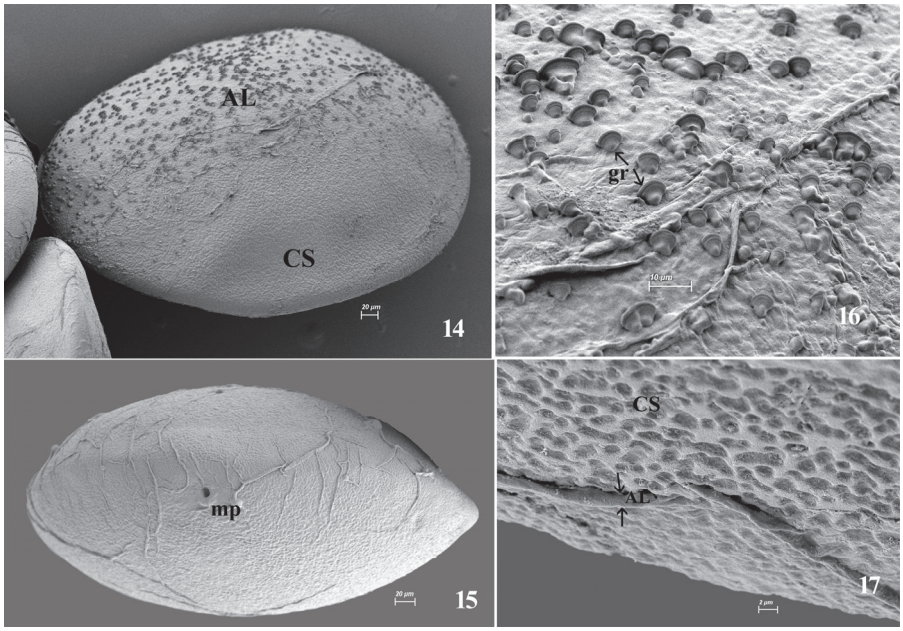
MATERIAL EXAMINED. ♀ imago, larva, Russian Federation, Primorsky Krai, Khankaisky district, Khanka Lake, near Kamen-Rybolov Village, 07.VI.2014, leg. V. Luborez.



Figs 8–13. Egg morphology of *Chankagenesia natans* Buldovsky: 8 – cluster of eggs bound by an adhesive layer; 9 – location of the micropyle, dorsal view; 10 – general shape without adhesive layer, dorsal view; 11 – lateral view; 12–13 – shape of the micropyles. CS – chorion surface; mo – micropylar opening; mp – micropyle.

EGG DISCRIPTION. The egg of *C. natans* has a somewhat oval shape in dorsal view (Figs 8–10). Dimensions: 451–521 μm along the major axis and 367–429 μm along the minor axis. In lateral view, the egg is shaped like a biconvex lens (thickness of 231–250 μm) with a thick peripheral border (Figs 11, 15). The exterior adhesive layer is thin, smooth-amorphous, 0.876– 0.939 nm thick (Fig. 17), and densely covered with mushroom-shaped granules (Fig. 16). Near the peripheral border, there is one micropyle per egg (Figs 9, 15). The edges of the micropyle are weakly prominent above the surface of the chorion (Figs 9, 12–13). The micropylar opening is nearly round, 7.3–9.0 μm wide and 7.1–8.7 μm high (Fig. 13). The eggs of *C. natans* are characterized by a funnel-form micropyle (Koss & Edmunds, 1974). The micropylar canal is tunnel-shaped with thick walls (Fig. 13). The chorion sculpture consists of shallow rounded depressions of various sizes whose arrangement regularly covers the entire surface of the chorion (Fig. 17).

DISTRIBUTION. South of the Russian Far East: Khanka Lake.



Figs 14–17. Egg morphology of *Chankagenesia natans* Buldovsky: 14 – general shape with adhesive layer, dorsal view; 15 – location of the micropyle, lateral view; 16 – shape of granules on the adhesive layer; 17 – chorionic sculpturing and thickness of adhesive layer. AL – adhesive layer; CS – chorion surface; mp – micropyle; gr – granules.

DISCUSSION

It is well known that there are three main morphological characteristics of eggs that can be useful for taxonomic purposes. These are chorion surface sculpture, attachment structures, and micropyle structure (Koss, 1968; Koss & Edmunds, 1974). Of the seven genera and 33 species of the family Palingeniidae, detailed descriptions of egg morphology using SEM are

known for only two species, *Palingenia longicauda* (Gaino & Bongiovanni, 1993; Landolt *et al*., 1995) and *Mortogenesia mesopotamica* (Soldon & Godunko, 2013). For *Cheirogenesia edmundsi* (Sartori & Elouard, 1999) and *Palingenia sublongicauda* (Tshernova, 1949) either single photographs or short descriptions are given. Having analyzed representatives of the genera *Anagenesi*a and *Chankagenesia*, as well as literature data for *Palingenia*, *Cheirogenesia,* and *Mortogenesia*, it can be noted that eggs of all known species of the family Palingeniidae have: 1) a lens shape (biconvex in lateral view) and are oval dorsally; 2) a thin adhesive layer covering them; 3) a rough or smooth surface of the chorion; and 4) a micropyle characterized by a funnel-shaped form.

When the eggs come in contact with water, the film separates, becomes sticky and elastic, and serves to attach the eggs to the substrate. The streamlined shape of the eggs favors rapid immersion in water, and the elastic film apparently protects the eggs from being washed away by the current.

The largest egg sizes were observed in *M. mesopotamica* (759–778 x 625–635 µm), and the smallest in *A. paradoxa* (280–352 x 260–320 µm). Egg sizes in *Ch. natans* were 451–521 x 367–429 µm; in *P. longicauda*, 418 x 375 µm; in *P. sublongicaudata*, 350–375 x 175–200 µm; and in *Cheirogenesia decaryi*, 300–360 µm in diameter.

Thus, on the basis of our data and literature survey, it can be noted that all morphological characteristics of eggs of representatives of five genera of the family Palingeniidae are not species-specific.

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Address: Federal Scientific Center of the East Asia Terrestrial Biodiversity (former Institute of Biology and Soil Science), Far East Branch of the Russian Academy of Sciences, 690022, Vladivostok-22, Russia.

E-mail: storozhenko@biosoil.ru web-site: http://www.biosoil.ru/fee